

Second Hand Smoke Exposure and Excess Heart Disease and Lung Cancer Mortality among Hospital Staff in Crete, Greece: A Case Study

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Abstract: Exposure to secondhand smoke (SHS) is a serious threat to public health, and a significant cause of lung cancer and heart disease among non-smokers. Even though Greek hospitals have been declared smoke free since 2002, smoking is still evident. Keeping the above into account, the aim of this study was to quantify the levels of exposure to environmental tobacco smoke and to estimate the attributed lifetime excess heart disease and lung cancer deaths per 1000 of the hospital staff, in a large Greek public hospital. Environmental airborne respirable suspended particles (RSP) of PM_{2.5} were performed and the personnel's excess mortality risk was estimated using risk prediction formulas. Excluding the intensive care unit and the operating theatres, all wards and clinics were polluted with environmental tobacco smoke. Mean SHS-RSP measurements ranged from 11 to 1461 µg/m³ depending on the area. Open wards averaged 84 µg/m³ and the managing wards averaged 164 µg/m³ thus giving an excess lung cancer and heart disease of 1.12 (range 0.23-1.88) and 11.2 (range 2.3-18.8) personnel in wards and 2.35 (range 0.55-12.2) and 23.5 (range 5.5-122) of the managing staff per 1000 over a 40-year lifespan, respectively. Conclusively, SHS exposure in hospitals in Greece is prevalent and taking into account the excess heart disease and lung cancer mortality risk as also the immediate adverse health effects of SHS exposure, it is clear that proper implementation and enforcement of the legislation that bans smoking in hospitals is imperative to protect the health of patients and staff alike.

Keywords: tobacco smoke pollution, lung cancer, hospital, ETS, occupational exposure, risk analysis, air pollution

Introduction

Second Hand Smoke (SHS), emitted from cigarettes is a known human toxin and carcinogen. It contains over 3000 chemicals out of which at least 50 are known or suspected to be carcinogenic, whilst over 200 are regarded as poisonous [1-2]. Its adverse effects on human health have been well documented and it is generally accepted that there is no safe level of exposure to cigarette smoke [3]. Tumor genesis, cardiovascular and respiratory diseases amongst others have been shown to develop and worsen in populations exposed to SHS [4-8]. It is also common knowledge that there is no lower threshold for tobacco carcinogenesis, either regarding lung cancer or tumors in other tissues that are indirectly exposed, since carcinogens absorbed in the lung are distributed

throughout the body and have been proven to create or aggravate tumor genesis [9-10].

In Greece it is estimated that 40% of the adult population are smokers and as stated in previous articles, and even though legislation regarding tobacco use exists, it is inadequately enforced and in certain cases bluntly ignored by the population [11-13]. One law, which is perceived to be correctly enforced, is the implementation of a smoking ban in health-care service centers such as public and private hospitals, health centers and pharmacies (Health Law 76017) [14]. According to the legislation (in force since August 2002) smoking is allowed only in designated areas, which should be provided with adequate air circulation for those who wish to smoke. The legislation also covered public services, educational institutions and public transport stations / public vehicles.

To date, there is little information regarding the exact extent of exposure to SHS in Greece, especially in areas where health services are provided. Therefore, the purpose of our study was firstly to measure SHS exposure in different areas throughout a large Greek public hospital and furtherly to estimate the excess lung-cancer and heart disease mortality risk of the hospital personnel due to their occupational exposure to SHS.

Methods

Aerosol Measurements and Questionnaire Procedures

A TSI SidePak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, Minnesota, USA) was used to sample and record the levels of respirable suspended particles (RSP) in the air. The SidePak uses a built-in sampling pump to draw air through the device and the particulate matter in the air scatters the light from a laser to assess the real-time concentration of particles less than 2.5 μm in micrograms per cubic meter, or $\text{PM}_{2.5}$. Particles of this size are released in significant amounts from burning cigarettes, are easily inhaled deep into the lungs, and are associated with pulmonary and cardiovascular disease and mortality [15]. SHS is not the only source of indoor particulate matter since dust, cooking and vehicle fumes also of this size. However, $\text{PM}_{2.5}$ monitoring is highly sensitive to SHS and elevated levels of such particles can be attributed almost solely to SHS [16,17]. Taking into account the background hospital ambient aerosol levels one can calculate the $\text{PM}_{2.5}$ levels which are attributed to SHS, following the formula: SHS-RSP levels = measured RSP – B, where B is the background aerosol level.

The SidePak was calibrated against a light scattering instrument, which had been previously calibrated and used in similar studies. The equipment was set to a ten-second sampling interval, which averages the measurements of the previous 10 seconds. The SidePak's flow rate was set to 1.7 litres per minute to ensure proper operation of the attached 2.5-micron impactor. In accordance with the Global Air Monitoring Study Protocol, a calibration factor of 0.32, which is suitable for tobacco smoke, was applied to all data [18].

Observational information was also recorded regarding evidence of current or previous smoking in the area, air volume and other factors that might affect the data (such as the use of solvents, and other chemicals). The monitor was strapped on the observer's shoulder, so that the air being sampled was within the occupants' normal breathing zone and sampling was discreet in order not to disturb the patients' and personnel normal behavior. For each clinic or ward, the first and last twenty seconds of logged data were removed because they were averaged with waiting room and stairway air. A total of fifteen minutes were spent in each area or ward inside the hospital throughout which the remaining data points were averaged to provide a mean $\text{PM}_{2.5}$ concentration. Measurements took place on weekdays during April 2006, during the morning shift (9 am-3 pm). The University Hospital of Crete, which is located in

Heraklion Greece, provides primary and secondary care to the population of Heraklion and tertiary care to the population of Crete and the nearby islands. The study was approved and acknowledged by the management of the Heraklion University Hospital but kept unknown from the staff and patients so as not to temporarily modify their smoking behavior.

Calculating Airborne Nicotine and Excess Lung Cancer Mortality Risk

According to the equations introduced by Repace et al., ambient aerosol nicotine levels (AANL) can be calculated from SHS-RSP levels (SHS-RSP: nicotine ratio = 10:1) and a workplace airborne nicotine concentration of 7.5 $\mu\text{g}/\text{m}^3$ gives an excess heart disease and lung cancer risk of 10/1000 and 1/1000 respectively in a linear dose-response relationship over the 40-year working lifetime [19-20]. The developed formula successfully has predicted actual mortality risk in population based studies and has been used previously to estimate excess occupational lung cancer risk and heart disease among hospitality workers [21-23].

Results

Indoor Air Concentrations of SHS-RSP

Table 1 depicts the state of occupational exposure to SHS inside the hospital. The exact SHS-RSP levels differed drastically between each area. No levels of SHS-RSP were

Table 1: Hospital indoor air concentrations of ETS (SHS-RSP)

Area	Mean levels ($\mu\text{g}/\text{m}^3$)	Range ($\mu\text{g}/\text{m}^3$)
Open wards	84	17 - 141
Closed wards		
Intensive Care Unit	12	2 - 23
Operating theatres	11	8 - 21
Staff rest rooms		
Smoking during measurements	628	453 - 1842
Smoking prior to measurements	169	11 - 919
Smoking not noticed	17	10 - 42
Management wards	164	29 - 901
Waiting Rooms	211	91 - 331
Main Lobby	57	25 - 84
Stairwells	147	24 - 253
Changing rooms		
Smoking noticed	1461	1374 - 2123
Smoking not noticed ²	84	17 - 141
Corridors		
Main	79	47 - 94
Secondary	59	19 - 98
Personnel only	50	7 - 104
Smoking room	1448	1051 - 2084
Outdoor reference	27	-

measured in only the intensive care unit and in operating theatres with mean SHS-RSP levels of 11 ug/m^3 , even lower than the outdoor reference level of 27 ug/m^3 . On the other hand, in most wards smoking was either noticed or evident. The mean SHS-RSP level of open wards was estimated at 84 ug/m^3 and ranged between 17 and 141 ug/m^3 with the lower readings found in children's wards (general paediatrics, paediatric haematology etc).

Staff rest rooms also were measured to have elevated SHS-RSP levels, depending on whether smoking was evident during or before the measurements were taken. In staff rest rooms, in which smoking was evident, SHS-RSP levels averaged 628 ug/m^3 and in those where smoking was not noticed 17 ug/m^3 . Stairwells and waiting rooms also were found to have elevated SHS-RSP levels of 147 and 211 ug/m^3 , respectively. Inside the hospital premises smoking is permitted only in the smoking room, which has inadequate air ventilation. There, exposure to SHS-RSP was inevitably high, averaging 1448 ug/m^3 . Even higher levels of SHS-RSP exposure, averaging 1461 ug/m^3 , were found in certain changing rooms in which smoking, although prohibited, was observed.

Calculated Nicotine Levels and Estimates of Excess Heart Disease and Lung Cancer Mortality

Taking into account the average levels of SHS one is exposed to while working in the hospital one can calculate the excess occupational lifetime risk of heart disease and lung cancer due to passive smoke exposure in the hospital.

Table 2: Estimated excess heart disease and lung cancer deaths per 1000 per 40 years due to hospital based SHS exposure¹

	Open wards	Closed wards	Management wards
Mean nicotine concentrations ³ in (ug/m^3)	8.4	N/a	17.6
Range in (ug/m^3)	1.7 - 14.1	N/a	4.1 - 91.3
Excess lung cancer deaths	1.12	N/a	2.35
Range	0.23 - 1.88	N/a	0.55 - 12.2
Excess heart disease deaths	11.2	N/a	23.5
Range	2.3 - 18.8	N/a	5.5 - 122
Total excess mortality	12.3	N/a	25.9
Range	2.5 - 20.7	N/a	6 - 134

¹Units of deaths per 1000 persons per 40 years

²Mean nicotine concentrations were calculated by using the data from Table 1 SHS-RSP: nicotine ratio of 10:1

³Total excess mortality = Lung cancer mortality + cardiovascular disease mortality

According to the ambient aerosol to ambient aerosol nicotine level (AANL) transformation formulas, the mean AANL was 8.4 ug/m^3 (range 1.7 to 14.1 ug/m^3) in open wards and 16.4 ug/m^3 (range 2.9 to 90.1 ug/m^3) in the hospital management wards. Table 2 depicts the estimated excess heart disease and lung cancer mortality risk due to SHS exposure in the hospital. On average 1.12 (0.23 to 1.88) workers per 1000 in open wards and 2.35 per 1000 (0.55-12.2) of management staff will die of lung cancer due to hospital SHS exposure. The excess lung cancer mortality risk in the ICU or operating theatres was not calculated because ambient aerosol measurements were even lower than outdoor baseline measurements and therefore could not be attributed to SHS. Excess heart disease mortality was calculated as tenfold that of the excess lung cancer cases and the accumulation of both led to the total excess mortality cases of 12.3 (2.5 to 20.7) and 25.9 per 1000 (6 - 134) of cases per 1000 per 40 years in open and management wards respectively.

Discussion

The levels of SHS exposure recorded in most areas of the hospital are alarming. It is evident that regulations for tobacco control are not being followed since exposure to SHS was evident in almost all areas. Patients, their relatives and friends, but also personnel were observed smoking during the days the measurements took place. Although waiting rooms and stairways do not have ashtrays and have prominent no-smoking signs, smoking was evident and exposure to SHS for those in waiting rooms was elevated. Personnel were found smoking in their rest rooms and also in their changing rooms so as to avoid being seen and reprimanded. The effects of SHS exposure on human health have been well documented and in this instance would not only affect the state of personnel health but also patients under treatment. Second-hand smoke has been found to worsen asthma attacks, chronic obstructive pulmonary disease, childhood cancer, adult cancer treatment and outcome, and even fertility among women who have undergone recent IVF [24-28].

SHS can now be added to the plethora of health hazards that doctors and nursing staff face. Back pain, long hours and exposure to radiation, latex, nitrous oxide and biological pathogens are just a few dangers that can reduce work efficiency and the health of the practitioners themselves [29-34]. In contrary to the above though, exposure to SHS can be completely avoided if legislated tobacco control measures are followed as designed.

Exposure to SHS in the workplace is not uncommon, especially for workers in hospitality venues, such as bars, cafes and restaurants. Regarding excess lung cancer mortality, similar levels of risk to those found in our study have been noted among workers in betting parlours and bowling alleys in the U.S (1-1.4 per 1000) and in cafes and bars in Spain [21-22]. In comparison to our findings workers in US bars ran a much higher excess risk of up to 14 per 1000 (before the smoking ban), while Hong Kong

hospitality workers have also been estimated at running an almost three times higher lung cancer and cardiovascular disease mortality risk in comparison to hospital personnel of our study but one should take into account the completely different setting between hospitality services and health provision services [23]. Globally, certain populations and specific working groups (as are employees in bars, cafes, casinos, pubs and restaurants) are exposed and subsequently affected by SHS. Implementing smoking bans has been found to reduce both occupational respiratory symptoms and population based risk of acute myocardial infarction and other cardiovascular events and the necessity of their implementation is scientifically warranted [35-36]. To our knowledge this is the first study that clearly demonstrates the connection between non-compliance to tobacco control measures for SHS exposure and mortality risk among workers in a hospital setting.

Certain assumptions were made during aerosol measurements and excess heart disease and lung cancer calculations. It is possible that lifetime exposure to SHS in the hospital differs due to our short window of measurements. It is possible that SHS levels during the afternoon and night shifts might be lower due to the reduction in personnel and visitors. However, the excess mortality risk might not necessarily be lower as we have not taken into account movement between wards and the time spent in staff rest rooms that provide a brief but extremely high exposure to SHS. Although it is difficult to extract generalizable conclusions in regards to other hospitals in Greece this study shows that PM_{2.5} measurements are a valid tool for measuring and monitoring SHS exposure in hospitals and an important means of surveillance of tobacco control legislations.

From our study, we are able to conclude that SHS in a typical hospital in Greece is prevalent and poses a threat to the health of patients and hospital personnel. Even though a policy that bans smoking in hospitals does exist, it is flagrantly ignored. When one considers the excess mortality risk and the immediate adverse health effects of SHS, it is imperative that the legislation that bans smoking within hospitals in Greece be enforced to protect not only patients but also medical and nursing staff from involuntary exposure to SHS and its ramifications.

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